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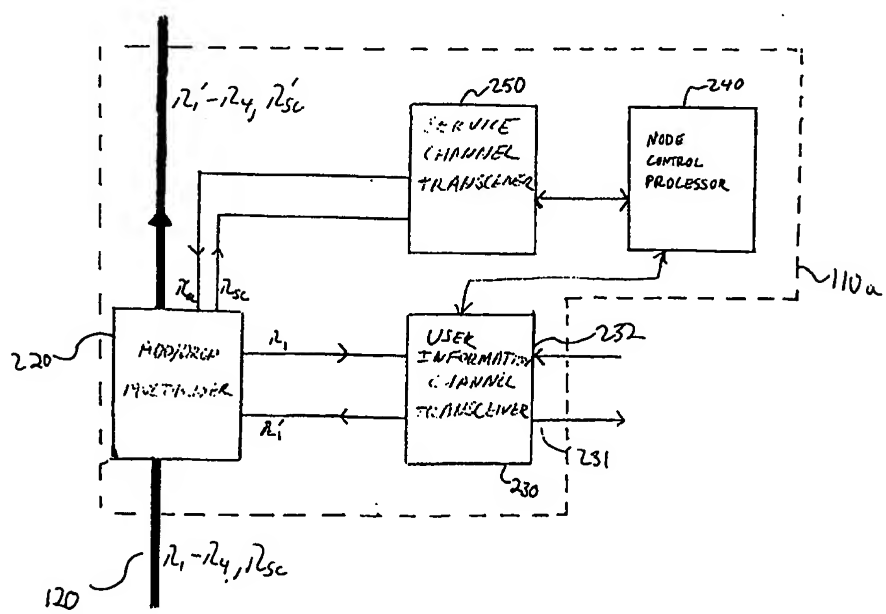

(57) Abstract

A WDM ring system is provided having a service channel at a wavelength different than the wavelengths associated with the user information channels. Accordingly, the service channel, which can carry diagnostic information related to the system, does not interfere or otherwise consume capacity reserved for the user information channels. Moreover, the present invention optionally provides a "short-reach" optical interface to external equipment, thereby avoiding costly optical regenerators.

WDM RING HAVING AN OPTICAL SERVICE CHANNEL

BACKGROUND OF THE INVENTION

The present invention is directed toward a system for monitoring a wavelength division multiplexed (WDM) system having a ring configuration.

Optical communication systems are a substantial and fast growing constituent of communication networks. Currently, the majority of optical communication systems are configured to carry an optical channel of a single wavelength over one or more optical waveguides. To convey information from plural sources, time-division multiplexing (TDM) is frequently employed. In time-division multiplexing, a particular time slot is assigned to each signal source, the complete signal being constructed from the portions of the signals collected from each time slot. While this is a useful technique for carrying plural information sources on a single channel, fiber dispersion and the need to generate high peak power pulses limit its capacity.

While capacity can be increased by laying additional fiber, in certain locations, such as metropolitan areas, the cost of laying additional fiber is prohibitive. Point-to-point wavelength division multiplexed (WDM) systems have thus been deployed in which a single fiber can carry numerous optical channels, thereby greatly increasing the capacity of the fiber. In metropolitan areas, WDM systems having a ring configuration can be used to provide high capacity data links between several nodes.

In order to insure proper operation of a WDM system, in particular one having a ring configuration, the WDM system must be monitored for faults. Moreover, information related to system performance must be transmitted throughout the system without interfering with the transmission of user information data.

SUMMARY OF THE INVENTION

Consistent with the present invention, a communication system is provided comprising a node coupled to a closed optical path. The node includes a plurality of first optical emitters, each supplying a corresponding one of a first plurality of user information channels to the closed optical path. Each of the first plurality of user information channels has a respective one of a first plurality of optical wavelengths. The node further includes a plurality of first optical receivers, each for sensing a corresponding one of a second plurality of user information channels from the closed optical path. Each of the second plurality of user information channels has a respective one of a second plurality of optical wavelengths, which can be the same as or different than the first plurality of wavelengths.

The node also comprises a service channel transmitter and receiver. The service channel receiver receives the optical service channel from the closed optical path, and the service channel transmitter transmits an optical service channel on the closed optical path at a wavelength different than the first and second pluralities of wavelengths. The transmitted optical service channel carries first service information, and the received service channel carries second service information, which can include either the same or different system diagnostic information than the first service information.

The communication system also comprises a second optical receiver, which is coupled to the closed optical path, and configured to sense one of the first plurality of user information channels from said closed optical path. Additionally, a second optical emitter is coupled to the closed optical path, and supplies one of the second plurality of user information channels to said closed optical path.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the present invention will be apparent from the following detailed description of the presently preferred embodiments thereof, which description should be considered in conjunction with the accompanying drawings in which:

Fig. 1 illustrates a block diagram of a WDM ring system in accordance with the present invention;

Fig. 2 illustrates a block diagram of a node in accordance with the present invention;

Fig. 3 illustrates an optical add/drop multiplexer included in the node shown in Fig. 2;

Fig. 4 illustrates a user information channel transceiver included in the node shown in Fig. 2;

Fig. 5 illustrates a service channel transceiver included in the node shown in Fig. 2; and

Fig. 6 illustrates a user information channel transceiver in accordance with a further embodiment of the present invention.

DETAILED DESCRIPTION

In accordance with the present invention, a WDM ring system is provided having a service channel at a wavelength different than the wavelengths associated with the user information channels. The service channel does not interfere or otherwise consume capacity reserved for the user information channel, and carries information for maintaining the system. Such information includes, for example, diagnostic and/or telemetry data, as well as monitor and control data. Moreover, in an alternative embodiment, the present invention advantageously provides an inexpensive "short-reach" optical interface to external equipment, thereby avoiding costly optical regenerators at the external equipment.

Further, since the present invention comprises a WDM ring, each wavelength can accommodate a particular transmission protocol. Thus, a single optical fiber, constituting part of the continuous optical path of the present invention, can simultaneously support many different protocols and data rates such as OC3, OC12, OC48, 100BT or native ATM or Ethernet.

Turning to the drawings in which like reference characters indicate the same or similar elements in each of the several views, Fig. 1 illustrates a WDM ring or loop system 10 comprising plurality of nodes 110-a to 110-d, for example, coupled to a closed or continuous optical path 120. Each of nodes 110-a to 110-d is configured to transmit on and receive from closed optical path 120 a plurality of user information channels, each at a respective wavelength. In addition, nodes 110-a to 110-d transmit and receive a service channel at a wavelength different than the user information channel wavelengths. Although four nodes are shown in Fig. 1, it is understood that any appropriate number of

nodes can be provided along closed optical path 120 in accordance with the present invention.

Fig. 2 illustrates node 110-a in greater detail. It is understood that nodes 110-b to 110-d have a similar construction as node 110-a. Node 110-a includes an add/drop multiplexer module 220 coupled to closed optical path 120. In the example shown in Fig. 2, add/drop multiplexer 220 is configured to extract service channel λ_{SC} and a single user information channel, λ_1, while allowing remaining user information channels, λ_2-λ_4, to continue propagating along closed optical path 120. Channel λ_1 is supplied to user information channel transceiver 230, while λ_{SC} is fed to service channel transceiver 250. User information channel transceiver 230 detects the data carried by channel λ_1 and outputs this data as an optical signal through port 231. The diagnostic information carried by service channel λ_{SC}, however, is output by service channel transceiver 250 to node control processor 240. This information can then be used to apprise node control processor 240 of the status of system 10, for example, and can also be used to control user information channel transceiver 230, as discussed in greater detail below.

User data input to node 110a is typically supplied as an optical signal to user information channel transceiver 230 through port 232. The user data is next transferred to user information channel λ_1' (typically at the same wavelength as channel λ_1) by user information channel transceiver 230 and output to add/drop multiplexer 220, which, in turn, adds channel λ_1' to closed optical path 220.

Diagnostic information related to node 110-a, for example, is typically obtained by node control processor 240 through various monitoring functions. The diagnostic information is supplied as electrical signals to service channel transceiver 250, which

outputs the service channel λ_{SC}' (typically at the same wavelength as λ_{SC}, but carrying different information) to add/drop multiplexer 220 for input to closed path 120 and transmission to one of nodes 110-b to 110-d.

Although extraction and addition of a single user information channel by node 110-a has been described above, it should be understood that additional user information channels can be added and extracted at the same node. In which case, a user information channel transceiver is typically provided for each additional user information channel to be added and extracted from closed optical path 120. Moreover, for security purposes, node 110-a can be located remote from add/drop multiplexer 220, and service channel λ_{SC} can be split off at user information channel transceiver 232 or at some intermediate point between add/drop multiplexer 220 and user information channel transceiver 232. In which case, the multiplexers and demultiplexers used for combining λ_{SC} and the user information channel can be housed in a module separate from add/drop multiplexer 220 and user information channel transceiver 232.

Fig. 3 illustrates optical add/drop multiplexer 220 in greater detail. Optical add/drop multiplexer 220 comprises an optical add/drop component 310, as described, for example, in U.S. patent application entitled "An Optical Add/Drop Multiplexer" to V. Mizrahi, filed October 23, 1997, attorney docket no. 212, incorporated herein by reference. Optical add/drop multiplexer typically adds and drops channels in the optical domain without regeneration through optical-to-electrical and subsequent electrical to optical conversions. As a result, element 120 in Fig. 1 constitutes a continuous optical path.

Returning to Fig. 3, optical add/drop component 310 has a first port 311 coupled to closed optical path for receiving channels λ_1-λ_4 and λ_{SC}. A second port 312 of optical add/drop component 310, in this example, outputs channels λ_1 and λ_{SC} to optical demultiplexer 320. Port 321 of optical demultiplexer 320 outputs channel λ_1 to transceiver 230, and port 322 outputs service channel λ_{SC} to service channel transceiver 250.

Optionally, as further shown in Fig. 3, optical add/drop multiplexer 220 further includes an optical multiplexer 330, which receives channels λ_1' and λ_{SC}' through ports 331 and 332, respectively. These channels are combined at output port 33 and supplied to port 313 of optical add/drop port 313, which, in turn, adds channels λ_1' and λ_{SC} to closed optical path 120. If additional channels are to be added or dropped from the same node, a corresponding number of optical add/drop components are typically added, each of which being coupled to a respective user information channel transceiver, as noted above. Moreover, although optical multiplexer 330 and optical demultiplexer 320 are shown in Fig. 3 located within optical add/drop multiplexer 220, it is considered within the scope of the invention that these components can be positioned remote from optical add/drop multiplexer 220. Moreover, multiplexer 330 and demultiplexer 320 can be positioned at any point intermediate optical add/drop multiplexer 220 and user information channel transceiver 230 or within user information channel transceiver 230.

User information channel transceiver 230 will next be described with reference to Fig. 4. User information channel transceiver 230 includes a first input port 401 receiving user information channel λ_1, for example. Typically, a receiver 404, including a photodetector, for example, is coupled to first input port 401, which converts the received

optical signals into electrical signals. Receiver 404 further includes circuitry that performs clock and data recovery from these electrical signals. The output of receiver 404 is coupled to a two-way electrical splitter 406, for example, which couples the output of receiver 404 to switch 426 and optional forward error correction (FEC) circuit 410. Data contained in the output of receiver 404 is to be output from node 110-a couples receiver 404 with FEC circuit 410. FEC circuit 410 is described, for example, in U.S. patent application entitled "Remodulating Channel Selectors For WDM Optical Communication Systems" to S. B. Alexander et al., filed October 21, 1997 and incorporated by reference herein. Optionally, FEC decoder circuit 410 decodes and corrects any errors present in data output from receiver 404. The output of FEC decoder circuit 410 is coupled to transmitter 412, which includes an optical emitter, such as a 1.3 micron laser, for outputting optical signals to an optical network in an office building, for example. Since the optical signals output from transmitter 412 are typically transmitted over relatively short distances, transmitter 412 is termed a "short reach interface." Moreover, these optical signals can be in a Synchronous Optical Network (SONET) format. In which case, the transmitter 412 obviates the need for costly SONET regenerator circuits.

Optical signals are further received from the optical network through second input port 232. Such optical signals are typically at 1.3 microns and are supplied to receiver 414, which outputs electrical signals in response thereto. The optical signals can be at a variety of transmission speeds and formats, such as OC3, OC12, OC48, 100BT, native Gigabit or Ethernet. Accordingly, the present invention is both bit rate and protocol transparent.

Optionally, the electrical signals output from receiver 414 are next encoded by FEC encoder circuit 416, as described, for example, in the patent application to Alexander et al., *supra*., which if coupled to laser driver circuit 418 by switch 426, supplies encoded electrical signals to laser drive circuit 418. Laser diode 420 is thus modulated by the output of laser driver 418 in accordance with the encoded electrical signals. Alternatively, laser diode 420 can be operated in a continuous wave (CW) mode and the output modulated with a Mach-Zehnder external modulator, as described, for example, in U.S. Patent No. 5,504,609, incorporated herein by reference. Typically, a coupler 424 supplies a relatively small fraction of light output from the laser diode 420 to wavelength control circuit 422 for adjusting the temperature, and thus the wavelength of light output from laser diode 420. The remaining light output from laser diode 420 is supplied to add/drop multiplexer 220.

It should be noted that in the absence of FEC circuits 410 and 416 electrical signals generated by receivers 404 and 414 are typically supplied directly to transmitter 412 and laser driver circuit 418, respectively.

User information channel transceiver 230 allows the user to route electrical signals generated by receiver 404 directly to laser driver 418. In which case, node control processor 240 outputs first control signals to microprocessor 408, which, in turn, outputs second control signals to switch 426 to couple receiver 404 to laser driver 418. Accordingly, laser driver 418 modulates laser diode 420 in accordance with electrical signals generated by receiver 404, which reflect the data received from closed optical path 120. The modulated output of laser diode 420, which is substantially the same as the optical input received from closed optical path 120, but in amplified, regenerated form, is

then placed back on closed optical path 120 via optical add/drop multiplexer 220. This feature may be useful in regenerating a relatively weak user information channel.

As shown in Fig. 6, in accordance with an alternative embodiment, switch 426 and electrical splitter 406 are omitted, and replaced by optical fiber 614 connected between couplers 610 and 612. In response to optical signals input from add/drop multiplexer 220 through port 401, receiver 404 outputs electrical signals, which are optionally decoded by FEC decoder circuit 410, to transmitter 412. In response to these electrical signals, transmitter 412 outputs further optical signals, which are supplied to receiver 414 via optical fiber 610. Receiver 414, in turn, outputs electrical signals corresponding to the received optical signals which are optionally encoded by FEC encoder circuit 416 and fed to laser driver 418 for modulating the output of laser diode 420. Thus, optical signals received through 401 are first converted to electrical signals, converted back to optical signals, converted back to electrical signals, and finally converted yet again to optical signals. As a result, the optical signals output from laser diode 420 are substantially identical to those received through input port 401, but are amplified and regenerated. The embodiment shown in Fig. 6 has a simpler construction, compared to the embodiment shown in Fig. 4, but cannot be readily reconfigured to receive signals from a network at port 232, as in Fig. 4.

Service channel transceiver 250 will next be described with reference to Fig. 5. Service channel λ_{SC} is typically supplied to a silicon photodiode (PD) 540 from add/drop mulitplexer 220. Photodiode 540, in turn, generates electrical signals, which are output to receiver 550, containing clock and data recovery circuits. Additional electrical signals are then output from receiver 550 to microprocessor 510, which extracts and appropriately

formats diagnostic information for output to node control processor 240. In response to such diagnostic information, node control processor 240 may actuate switch 426. Alternatively, the user can actuate these switches by supplying appropriate signals to node control processor 240.

Diagnostic information, for example, supplied by node control processor 240, which can be different than the diagnostic information transmitted on service channel λ_{SC}, is typically supplied to microprocessor 510, which outputs appropriate signals to laser driver 520. In response to these signals, laser drive 520 generates electrical signals of sufficient duration and magnitude to modulate laser diode 530. The optical signals thus output from laser diode 530 and supplied to add/drop multiplexer 220 reflect the diagnostic information supplied from node control processor 510. Typically, the optical output from laser diode 530, λ_{SC}', is at the same wavelength as λ_{SC}, and is generally within a range of 1260 to 1360 nm, while the user information channels are within a range of 1500-1650 nm. However, both service and user information channels can be within the 1500-1650 nm range (e.g., λ_{SC} can be at 1533 or 1565) or in the 1260 to 1360 nm range.

While the foregoing invention has been described in terms of the embodiments discussed above, numerous variations are possible. Accordingly, modifications and changes such as those suggested above, but not limited thereto, are considered to be within the scope of the present invention. For example, although a single fiber optical ring is illustrated in Fig. 1, it is considered within the scope of the invention that an additional continuous optical ring path can be provided interconnecting nodes 110-a to 110-d with the additional signals typically propagate in the second ring in a direction opposite the first ring.

What is claimed is:

1. A communication system comprising:

a node coupled to a closed optical path, said node comprising:

a plurality of first optical emitters, each supplying a corresponding one of a first plurality of user information channels to said closed optical path, each of said first plurality of user information channels having a respective one of a first plurality of optical wavelengths;

a plurality of first optical receivers, each for sensing a corresponding one of a second plurality of user information channels from said closed optical path, each of said second plurality of user information channels having a respective one of a second plurality of optical wavelengths;

a service channel transmitter for transmitting an optical service channel carrying first service information on said closed optical path including diagnostic information related to said communication system, said optical service channel being at a wavelength different than said first and second pluralities of wavelengths; and

a service channel receiver receiving said optical service channel carrying second service information from said closed optical path; and

a second optical emitter coupled to said closed optical path, said second optical emitter supplying one of said second plurality of user information channels to said closed optical path.

2. A communication system in accordance with claim 1, further comprising:

a second optical receiver coupled to said closed optical path, said second optical receiver configured to sense one of said first plurality of user information channels from said closed optical path.

3. A communication system in accordance with claim 2, wherein said node is a first node, said communication system further comprising:

a second node coupled to said closed optical communication path, said second node comprising said second optical receiver; and

a third node coupled to said closed optical communication path, said third node comprising said second optical emitter.

4. A communication system in accordance with claim 2, wherein said node is a first node, said communication system further comprising a second node coupled to said optical communication path, said second node comprising said second optical receiver and said second optical emitter.

5. A communication system in accordance with claim 1, wherein said node further comprises an add/drop optical component coupled to said closed optical path, said add/drop component comprising:

a first port being coupled to closed optical path, said first port being configured to receive said second plurality of user information channels and said service channel carrying said second service information from said closed optical path;

a second port being configured to supply said one of said second plurality of user information signals to a corresponding one of said plurality of first optical receivers and supply said optical service channel carrying said second service information to said service channel receiver;

a third port receiving said one of said first plurality of user information channels from a corresponding one of said plurality of first optical emitters, said third port further receiving said optical service channel carrying said first service information from said service channel transmitter; and

a fourth port coupled to said closed optical path, said fourth port supplying to said closed optical path said one of said first plurality of user information channels and said optical service channel carrying said first service information.

6. A communication system in accordance with claim 5, further comprising:

an optical demultiplexer having a first port coupled to said second port of said optical add/drop component, said first port receiving said one of said first plurality of user information signals and said optical service channel with said second service information, said optical demultiplexer further having a second port outputting said one of said first plurality of user information signals to said corresponding one of said first plurality of optical receivers, and a third port outputting said service channel carrying said second service information to said service channel receiver.

7. A communication system in accordance with claim 5, further comprising:

an optical multiplexer having a first port coupled to said corresponding one of first optical emitters and receiving said one of said first plurality of user information channels, a second port coupled to said service channel transmitter and receiving said optical service channel carrying said service channel information, and a third port configured to output said one of said first plurality of user information channels and said optical service channel carrying said first service channel information to said third port of said add/drop component.

8. A communication system in accordance with claim 1, further comprising:

a processing circuit coupled to said service channel transmitter and said service channel receiver, said processing circuit supplying said first service information to said service channel transmitter and receiving said second service information from said service channel receiver.

9. A communication system in accordance with claim 1, wherein said node further comprising:

a second optical receiver configured to receive first optical signals and generate first electrical signals in response thereto, one of said plurality of first optical emitters being coupled to said second optical receiver and supplying a corresponding one of said first plurality of user information channels in response to said first electrical signals;

a third optical emitter coupled to one of said plurality of first optical receivers, said one of said first optical receivers outputting second electrical signals to said third optical emitter in response to said one of said second plurality of user information channels, said third optical emitter outputting second optical signals in accordance with said third electrical signals.

10. A communication system in accordance with claim 9, wherein said one of said plurality of first optical emitters comprises a laser, said node further comprising:

a laser drive circuit coupled to said second optical receiver and said laser, said laser drive circuit supplying second electrical signals to said laser to thereby selectively actuate said laser and generate said one of said plurality of user information channels.

11. A communication system in accordance with claim 9, wherein said one of said plurality of first optical emitters comprises a laser, said laser being externally modulated in accordance with said first electrical signals.

12. A communication system in accordance with claim 1, wherein said first and second pluralities of user information channels have wavelengths within 1500-1650 nm, and said optical service channel has a wavelength within a range of 1300-1400 nm.

13. A communication system in accordance with claim 1, wherein said first and second pluralities of user information channels and said optical service channel have wavelengths within a range of 1500-1650 nm.

14. A communication system in accordance with claim 1, wherein said first and second pluralities of user information channels and said optical service channel have wavelengths within a range of 1300-1400 nm.

15. A communication system in accordance with claim 1, wherein said first and second pluralities of user information channels and said optical service channel are selected within the ranges of 1300-1400 nm and 1500-1650 nm.

16. A communication system in accordance with claim 5, wherein said node comprises a module, said module comprising said add/drop optical component, at least one of said plurality of first optical emitters and at least one of said plurality of first optical receivers.

17. A communication system in accordance with claim 5, wherein said communication system comprises a first module including said add/drop component, and a second module comprising at least one of said plurality of first optical emitters and at

least one of said plurality of first optical receivers, said first module being located remote from said second module.

18. A communication system in accordance with claim 6, wherein said communication system comprises a first module including said add/drop component, and a second module comprising at least one of said plurality of first optical emitters and at least one of said plurality of first optical receivers, said first module being located remote from said second module, and said optical demultiplexer being coupled between said first and second modules.

19. A communication system in accordance with claim 6, wherein said communication system comprises a first module including said add/drop component, and a second module comprising at least one of said plurality of first optical emitters and at least one of said plurality of first optical receivers, said first module being located remote from said second module, and said optical multiplexer being coupled between said first and second modules.

20. An optical device, comprising:

an add/drop multiplexer coupled to a closed optical path, said closed optical path carrying a plurality of user information optical channels, each at a respective wavelength, said add/drop multiplexer having a first port connected to said closed optical path, a second port outputting one of said plurality of user information optical channels, a third port receiving said one of said plurality of user information optical channels, and a fourth port coupled to said optical path supplying said one of said plurality of user information optical channels to said optical path;

a receiver coupled to said second port of said add/drop multiplexer, said receiver generating electrical signals in response to said one of said plurality of user information optical channels carrying first information;

an optical emitter coupled to said third portion of said add/drop multiplexer; and

a switching circuit coupled to said receiver and said optical emitter to selectively supply said electrical signals to said optical emitter, said optical emitter emitting said one of said plurality of user information channels in response to said electrical signals.

21. An optical device in accordance with claim 20, wherein said receiver is a first receiver, said optical device further comprising:

a second optical receiver configured to receive optical signals and generate third electrical signals in response thereto, said second optical receiver being coupled to said switching circuit, said switching circuit selectively supplying one of said first and third electrical signals to said optical emitter.

22. An optical communication device comprising:

an add/drop multiplexer coupled to a closed first optical path, said closed optical path carrying a plurality of user information optical channels, each at a respective wavelength, said add/drop multiplexer having a first port connected to said closed optical path, a second port outputting one of said plurality of user information optical channels, a third port receiving said one of said plurality of user information optical channels, and a fourth port coupled to said optical path supplying said one of said plurality of user information optical channels to said optical path;

a first receiver coupled to said second port of said add/drop multiplexer, said receiver generating first electrical signals in response to said one of said plurality of user information optical channels carrying first information;

a first optical emitter coupled to said first receiver and receiving said first electrical signals, said first emitter outputting optical signals in accordance with said first electrical signals;

a second optical communication path having a first end portion coupled to said first optical emitter and a second end portion;

a second receiver coupled to said second end portion to thereby receive said optical signals from said first optical emitter, said second receiving generating second electrical signals in response to said optical signals; and

a second optical emitter coupled to said second receiver and receiving said second electrical signals, said second optical emitter outputting said one of said plurality of user information optical channels to said third port of said add/drop multiplexer in response to said second electrical signals.

23. A communication system comprising:

a closed optical path;

a first optical emitter coupled to said closed optical path, said first optical emitter being configured to supply a first user information channel at a first wavelength and carrying one of a first transmission protocol and a first transmission rate;

a first optical receiver coupled to said closed optical path and spaced from said first optical emitter, said first optical receiver sensing said first user information channel;

a second optical emitter coupled to said closed optical path, said second optical emitter being configured to supply a second user information channel at a second wavelength and carrying one of a second transmission protocol and a second transmission rate;

a second optical receiver coupled to said closed optical path and spaced from said second optical emitter, said second optical receiver sensing said second user information channel;

a service channel transmitter coupled to said closed optical path for transmitting an optical service channel carrying service information on said closed optical path including diagnostic information related to said communication system, said optical service channel being at a wavelength different than said first and second wavelengths; and

a service channel receiver sensing said optical service channel.

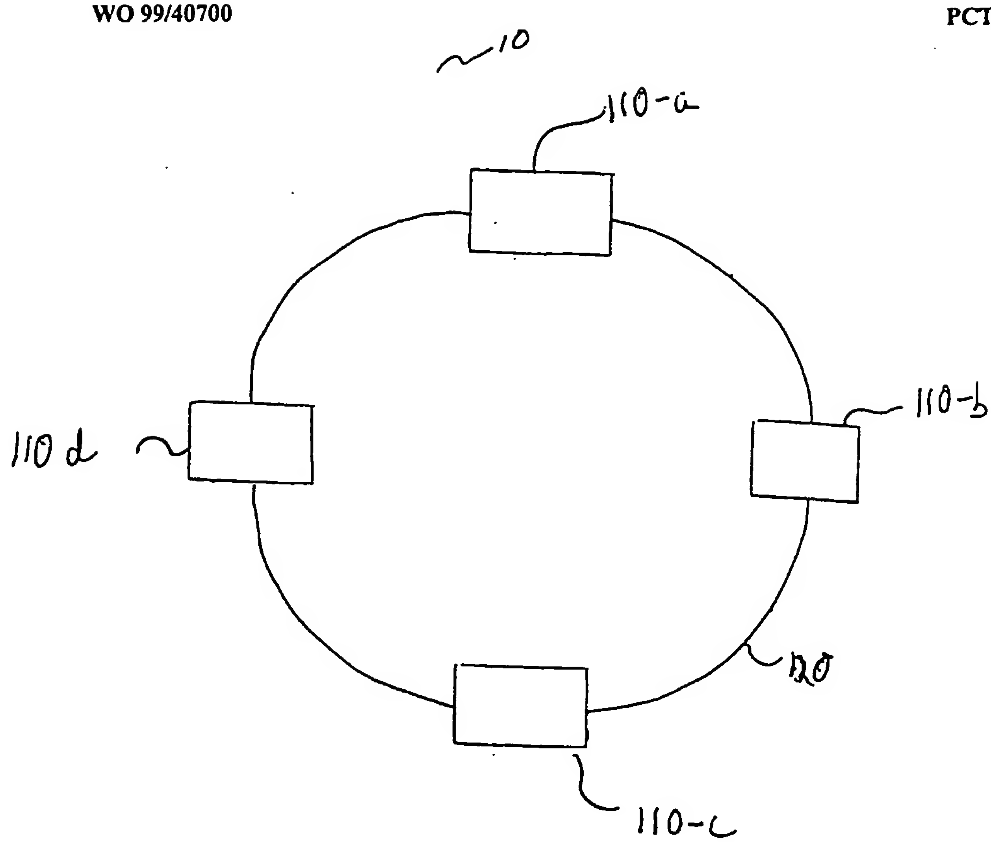

FIG 1

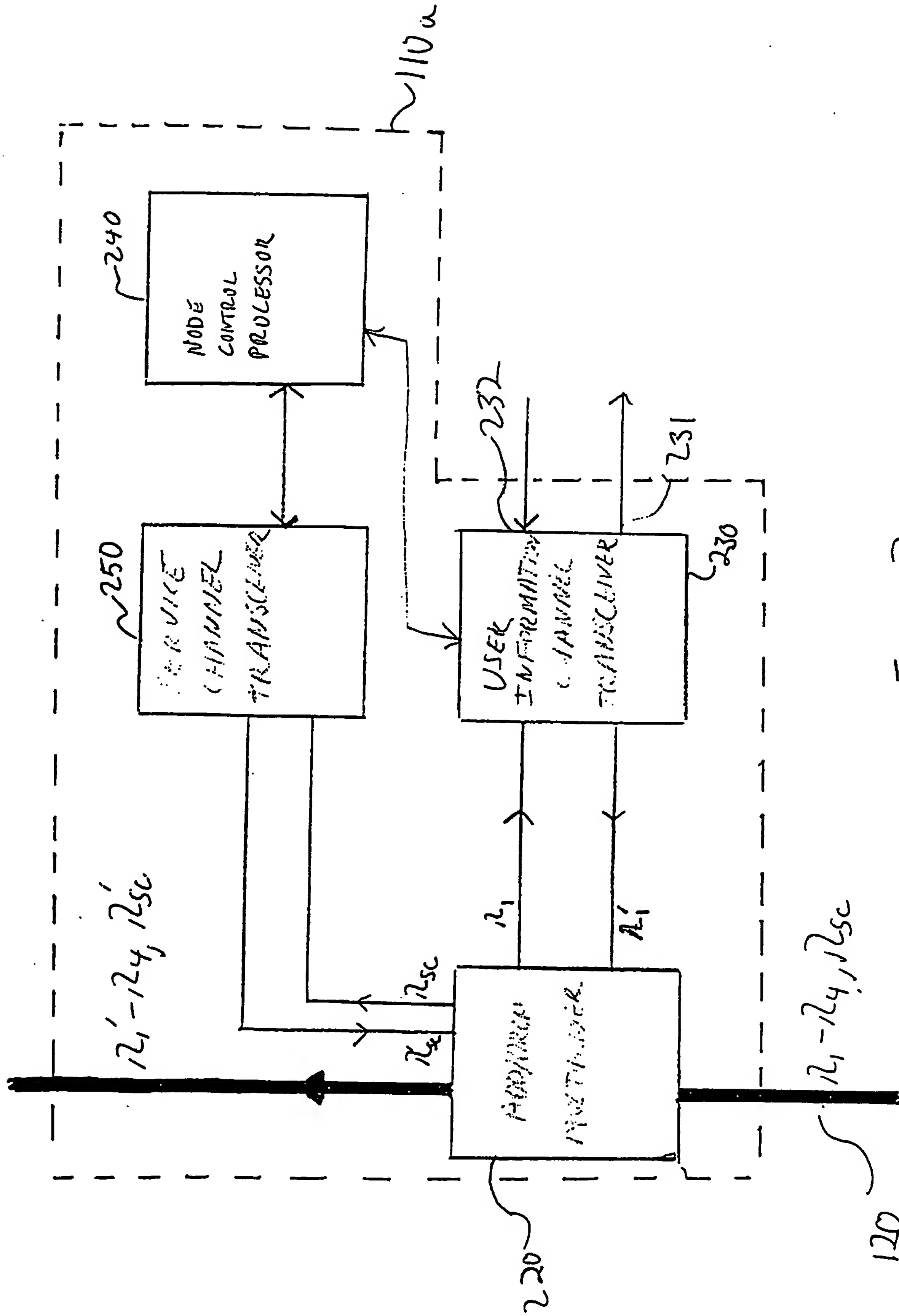

Fig. 2

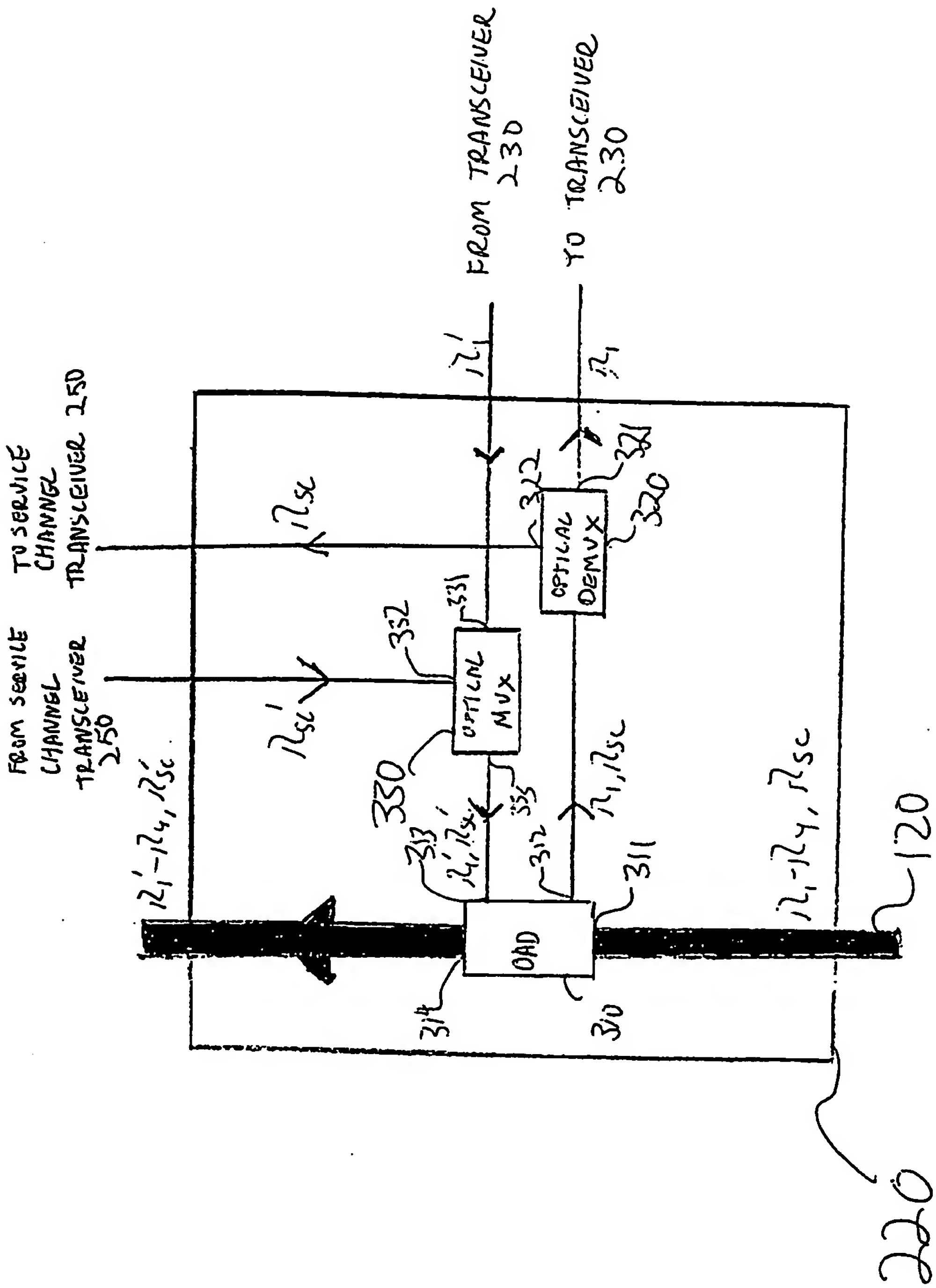
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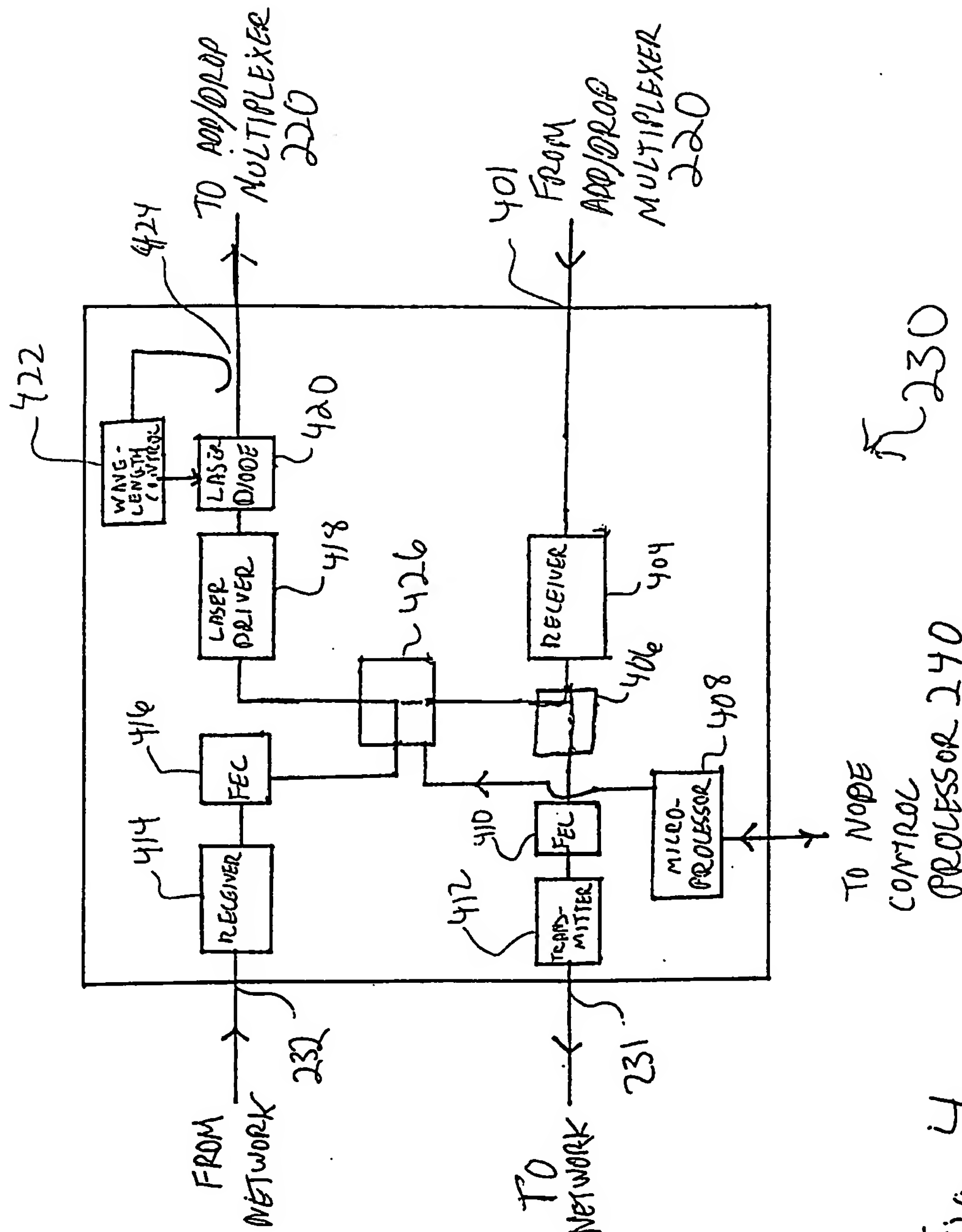
Fig. 3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FEC
414
RECEIVER
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Fig. 4

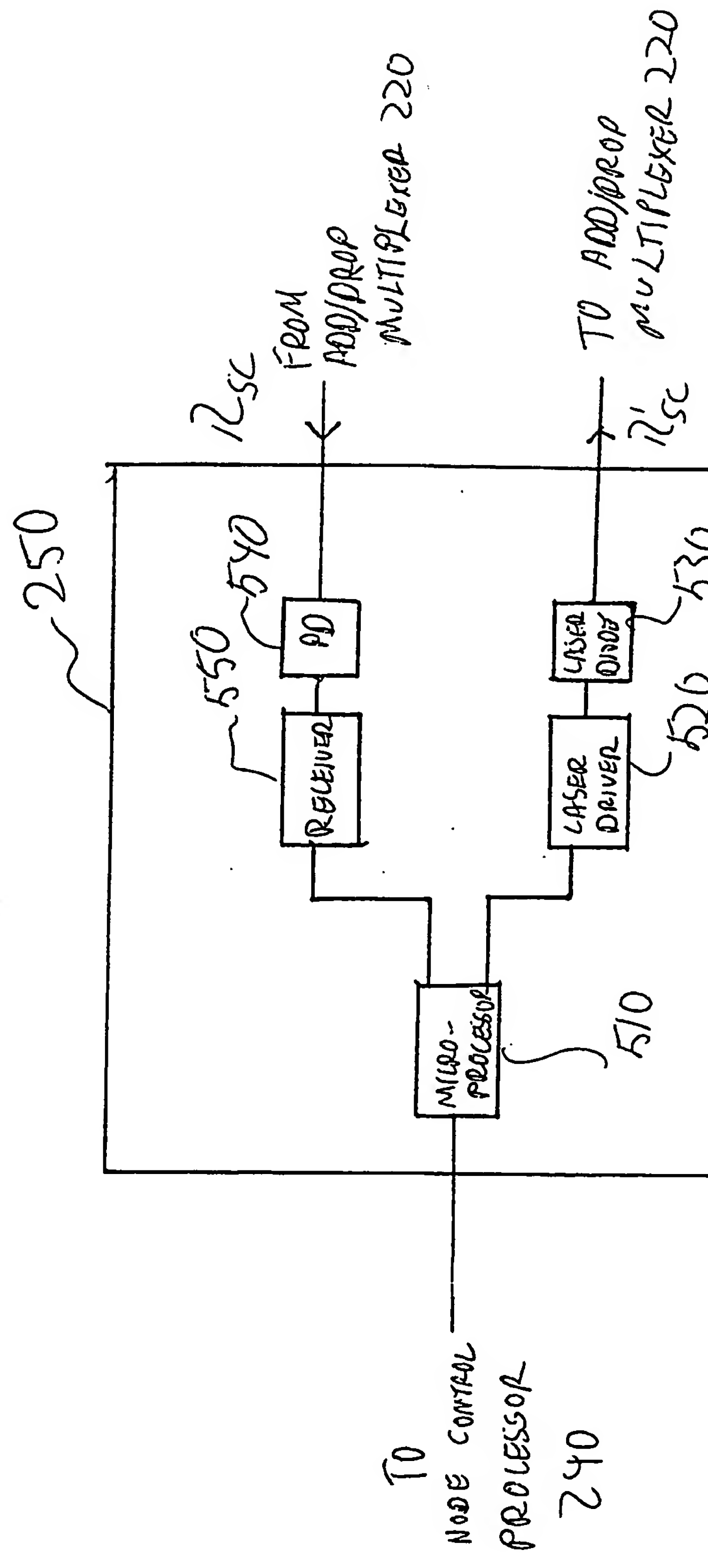
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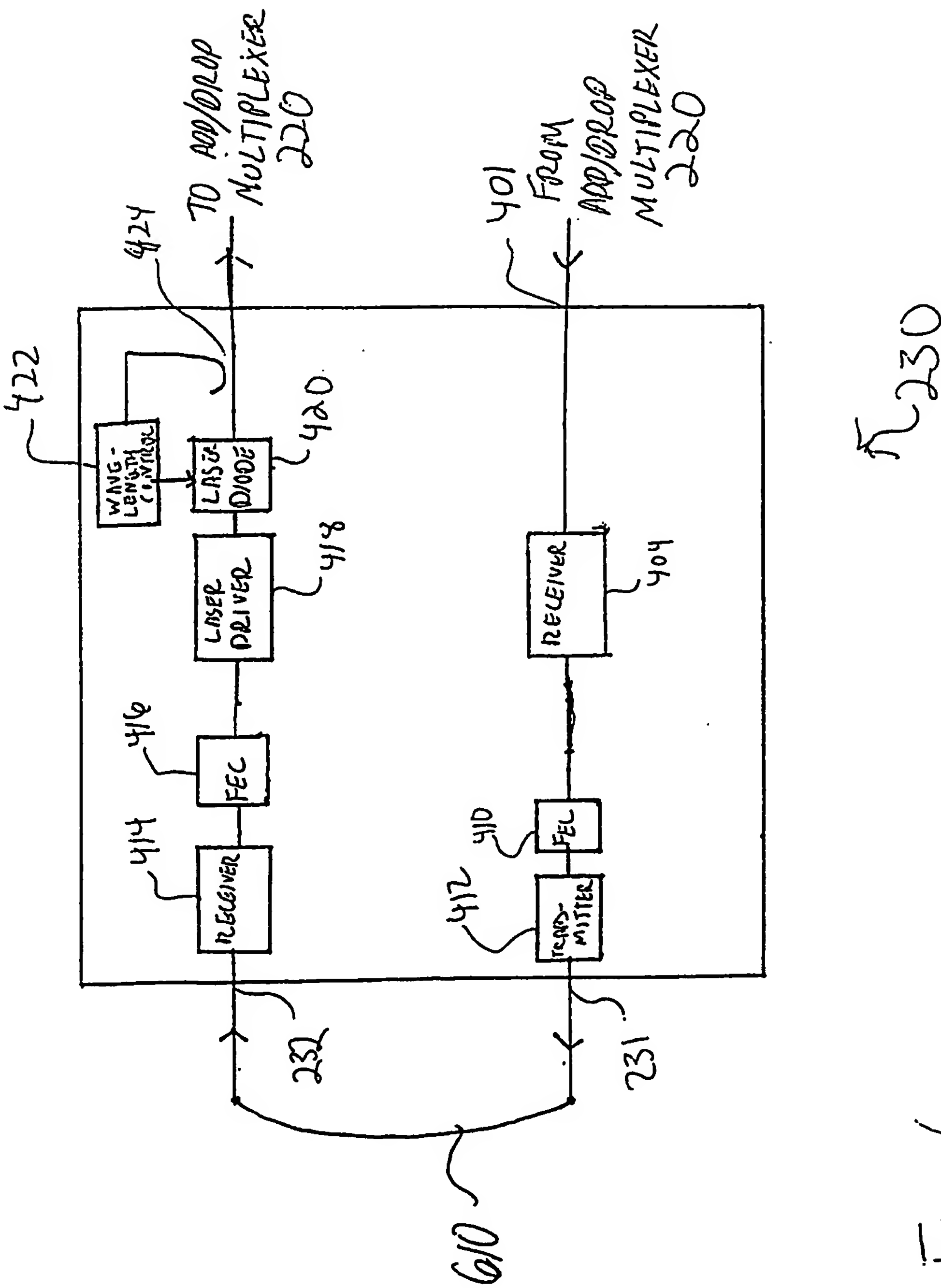
Fig. 5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416
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404
FEC
410
TRANS-MITTER
412
232
231
610
230

Fig. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/02507

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04J14/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04J H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 769 859 A (PIRELLI CAVI SPA) 23 April 1997	1-4, 12-15,23
Y	see column 1, line 10 - line 21 see column 6, line 49 - column 7, line 42; figure 2 see column 8, line 3 - line 13 see column 8, line 39 - line 47 see column 10, line 6 - line 19 see column 12, line 48 - line 56; figure 5 ---	5-8, 16-19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 May 1999	01/06/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Roldán Andrade, J

3

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/02507

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	CHANG G -K ET AL: "MULTIWAVELENGTH RECONFIGURABLE WDM/ATM/SONET NETWORK TESTBED" JOURNAL OF LIGHTWAVE TECHNOLOGY, vol. 14, no. 6, 1 June 1996, pages 1320-1340, XP000598536 see page 1320, right-hand column, line 3 - line 9 see page 1321, right-hand column, line 23 - page 1322, left-hand column, line 25; figure 2 see page 1330, left-hand column, line 5 - line 15; figure 19 see page 1335, left-hand column, line 17 - right-hand column, line 9 ---	1-4, 9-11, 20-23
X	WO 95 20847 A (BARNSLEY PETER EDWARD ;MCGUIRE ALAN (GB); BRITISH TELECOMM (GB); H) 3 August 1995	20,21,23
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Y	DE 197 00 682 A (FUJITSU LTD) 22 January 1998	5-7, 16-19
A		23
	see column 1, line 3 - line 7 see column 7, line 37 - column 8, line 41; figures 4,7 ---	
A	EP 0 721 275 A (NIPPON ELECTRIC CO) 10 July 1996 see column 4, line 4 - line 54 -----	1-4,8, 12-15

3

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Information on patent family members

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